PREVIOUSLY…

Molecular basis of colour vision (how DNA sequence of opsins determines colour sensitivity)

THIS LECTURE:

the evolutionary history of colour vision

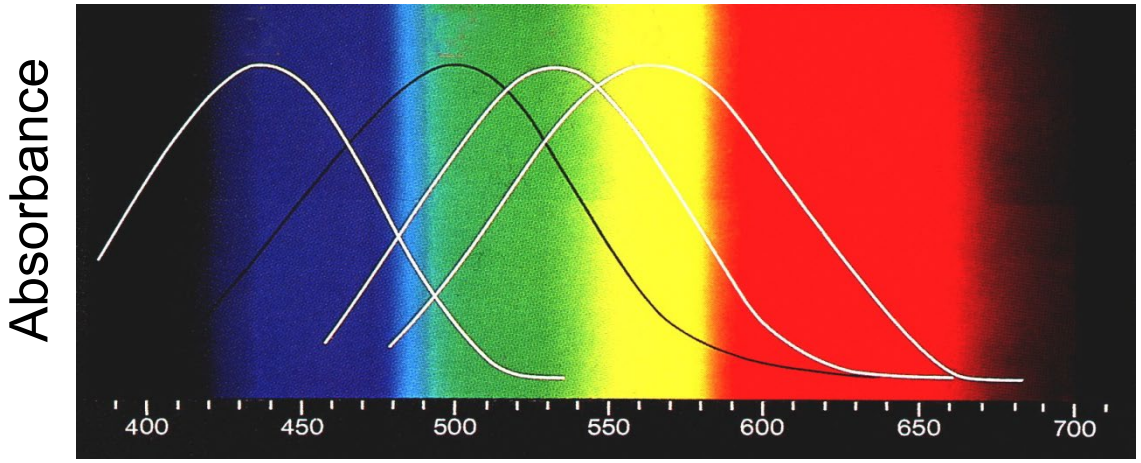
What is colour vision?

- visible light: electromagnetic waves that we can see

- ability to discriminate between different wavelengths of light
- mediated by cone photoreceptors in retina

Requirements for colour vision

- different wavelengths must be individually sampled and compared with each other
- wavelengths sampled/absorbed by cones
- absorbance = spectral sensitivity



- minimum requirement = 2 different types of cones

5 opsin classes based on amino acid compositions

- 4 cone opsin classes (1 cone = 1 opsin):

Short wavelengths

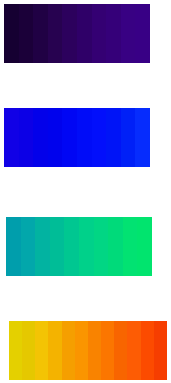
Long wavelengths

SWS1

SWS2

MWS

M/LWS



- **not all in all vertebrates**
- MWS = ancestral opsin

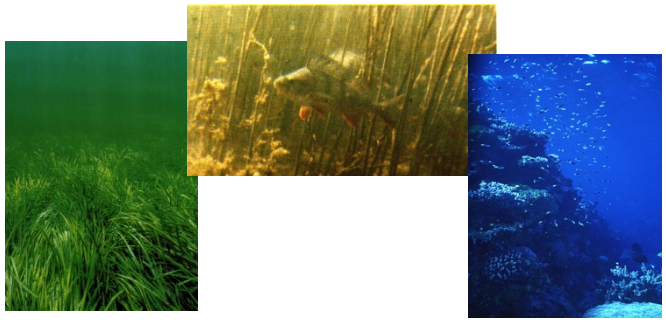
- 1 rod opsin class: rhodopsin (RH1)

colour vision relates to ecology…

- visual tasks: finding food, detecting/escaping predators, catching prey, mate choice etc…



- light environment (activity patterns + habitat)




…and evolution

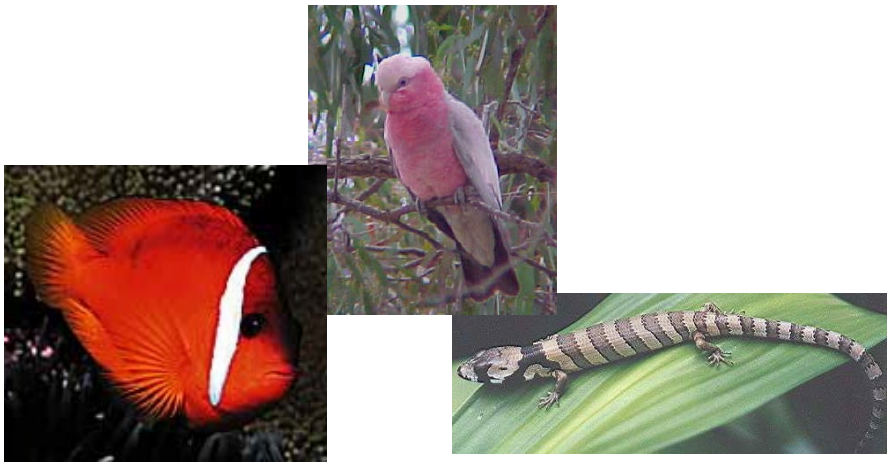
Colour vision

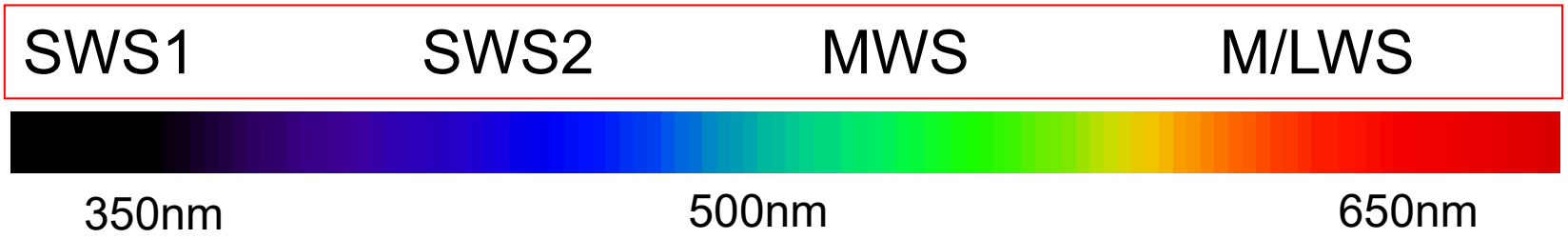
SWS1 SWS2 MWS M/LWS

350nm 500nm 650nm

Which species have which opsins?

Colour vision – non mammalian

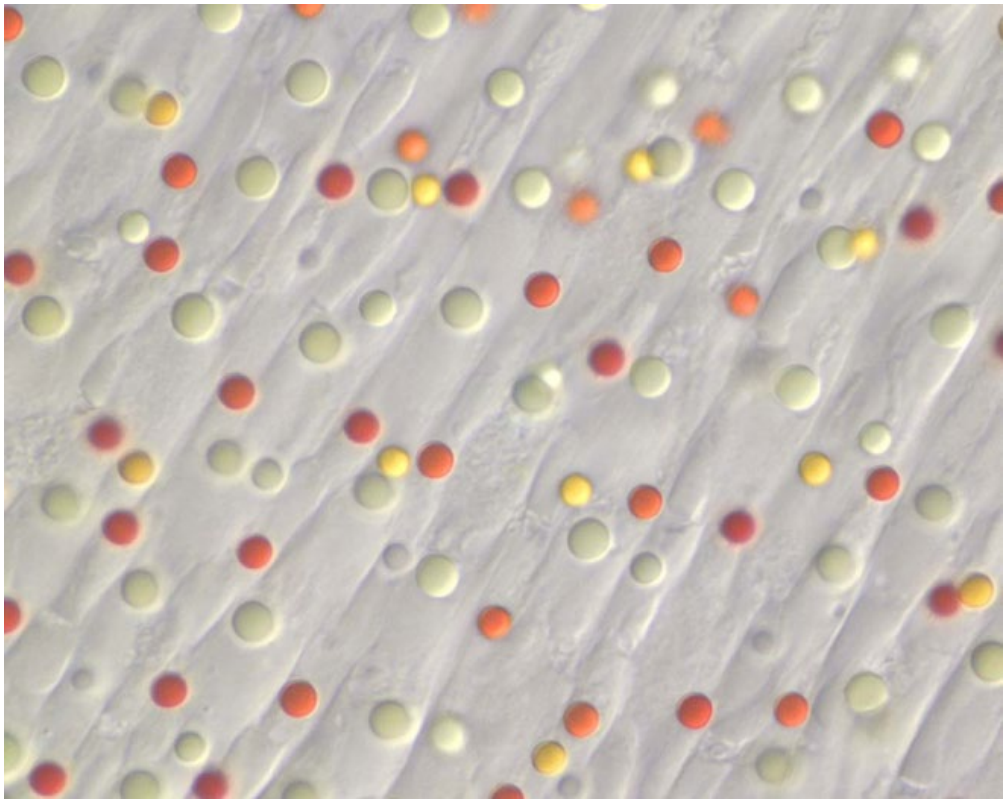




- four classes of cone opsins, present in ancestral vertebrates = tetrachromacy
- coloured oil droplets (digression)

Avian and reptilian oil droplets

- refractile organelles in cone inner segment
- filtering molecule = carotenoid



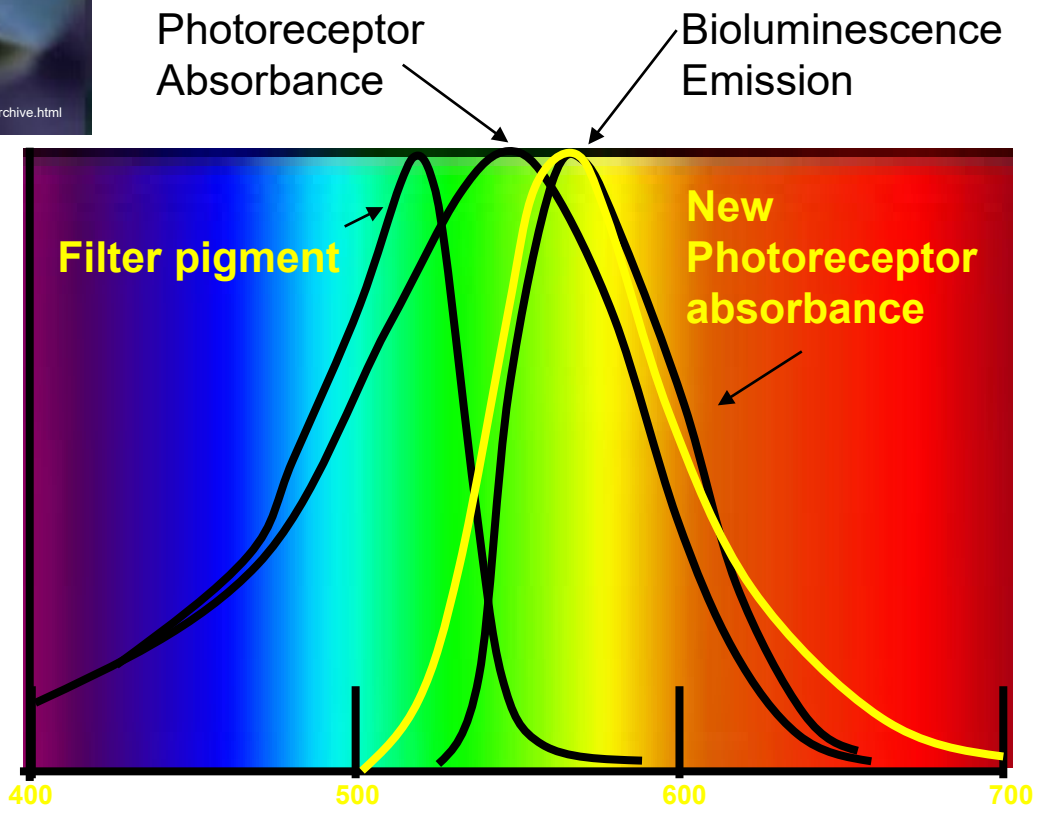
- Different types of cones paired with different types of oil droplets

SWS1		T-type (transparent)
SWS2		C-type (clear)
MWS		Y-type (yellow)
LWS		R-type (red)

Filtering pigments may tune sensitivity

Twilight-active fireflies *Photinus pyralis* and *Photinus scintillans* emit bioluminescence

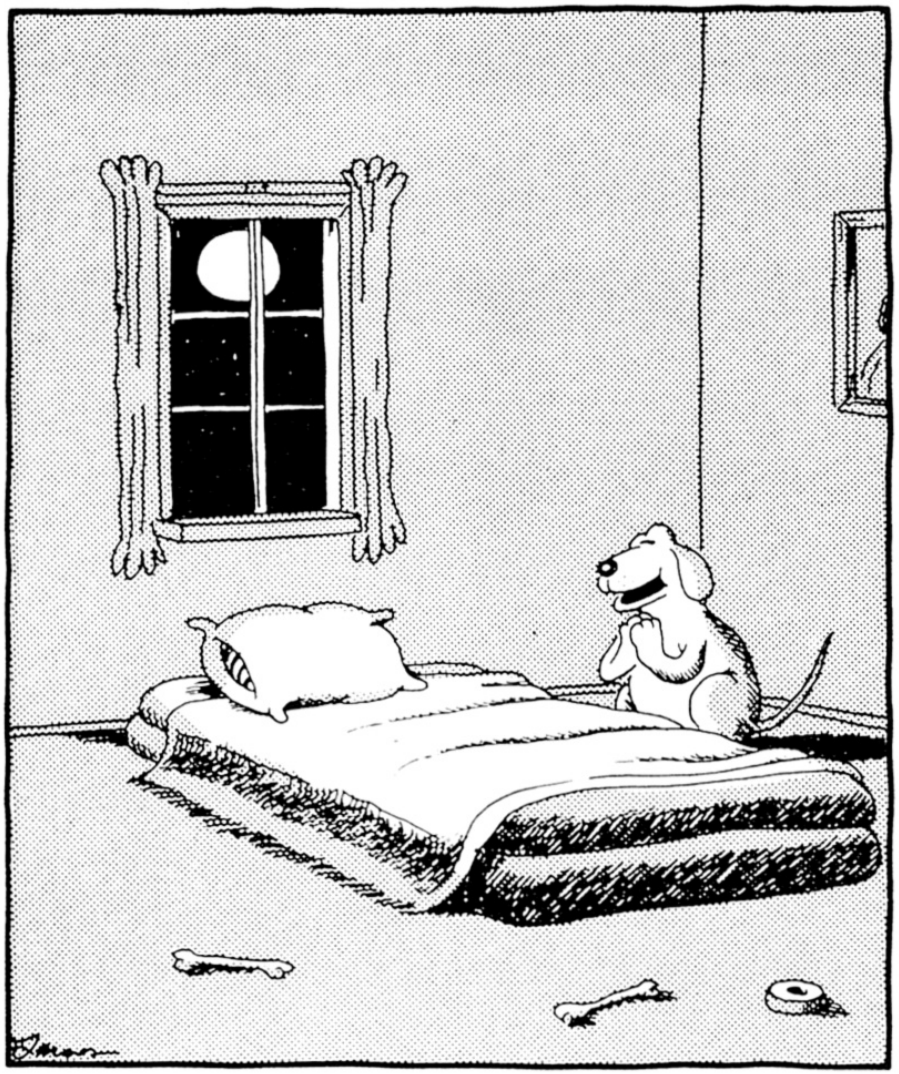
Interaction between visual pigment and a pink filtering pigment tunes absorbance to emission



Avian and reptilian oil droplets

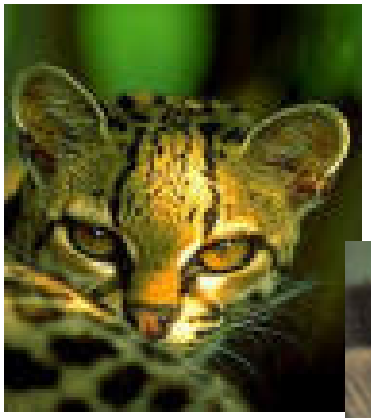
Bird species	**Foraging strategy**	**Oil droplet**
shag, shearwater	fish underwater	20% red + orange
gull, tern	water surface	50-80% red + orange

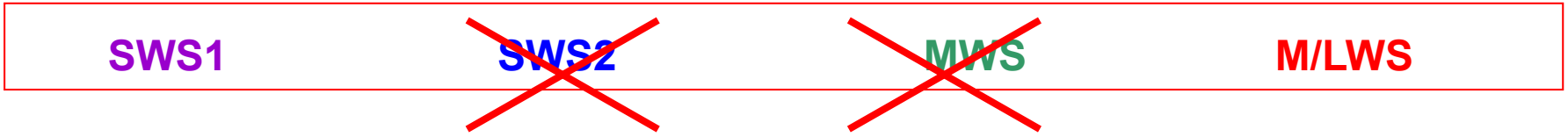
Colour vision – placental mammals



"... And please let Mom, Dad, Rex, Ginger, Tucker, me, and all the rest of the family see color."

Colour vision – placental mammals





- Two cone opsin genes LOST (nocturnality)
- Two cone opsin genes retained = dichromacy

Placentals: terrestrial vs marine

- M/LWS >>> SWS1
- SWS1 = 5 -10% cone population

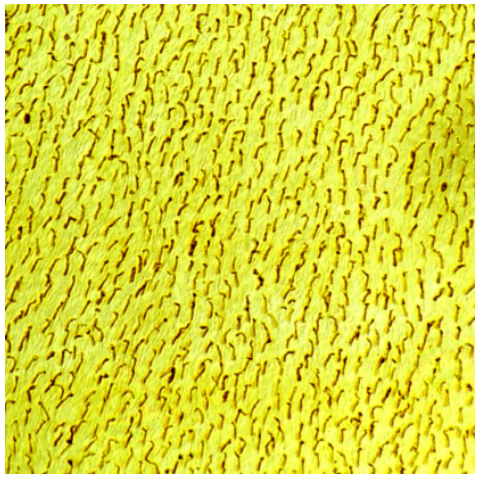
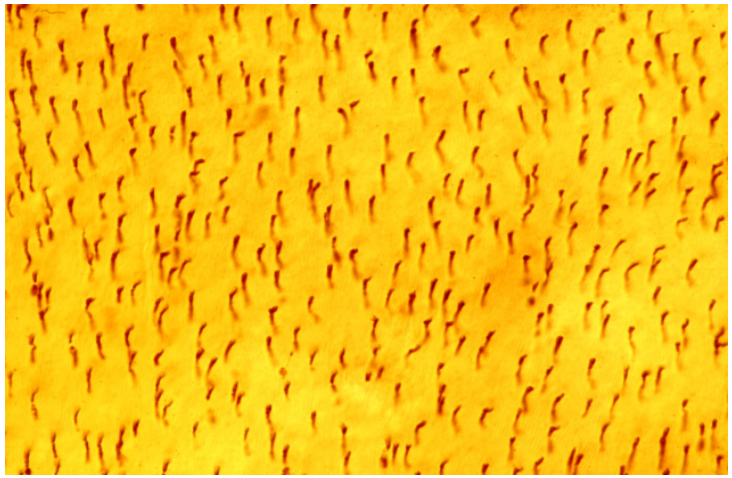
M/LWS SWS

wolf

M/LWS SWS

bearded seal

Placentals: terrestrial vs marine

	Sheep	Pilot whale
M/LWS		
SWS		

Why are marine mammals monochromats?

Underwater environment is blue, so marine mammals should have retained the SWS opsin

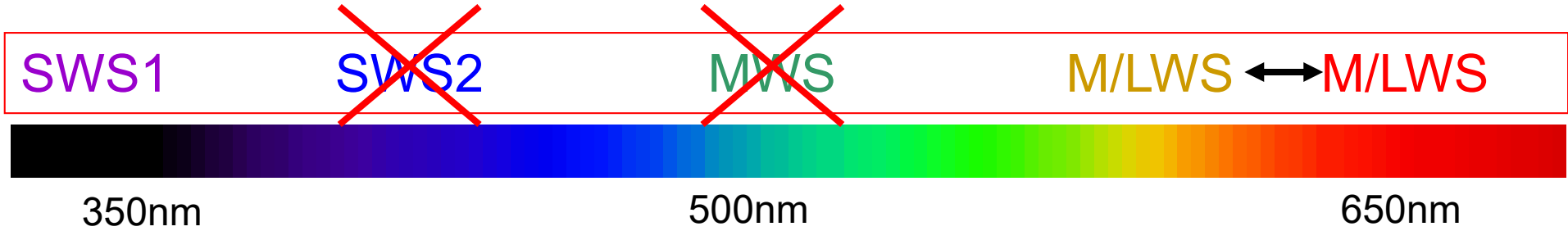
Interaction between rod and cone, low light levels, other senses…

Adaptation to marine environment:

- **Reflection of downwelling light**
- **Shallow waters are red-shifted – loss of SWS opsin happened early in evolution**

Colour vision – primates

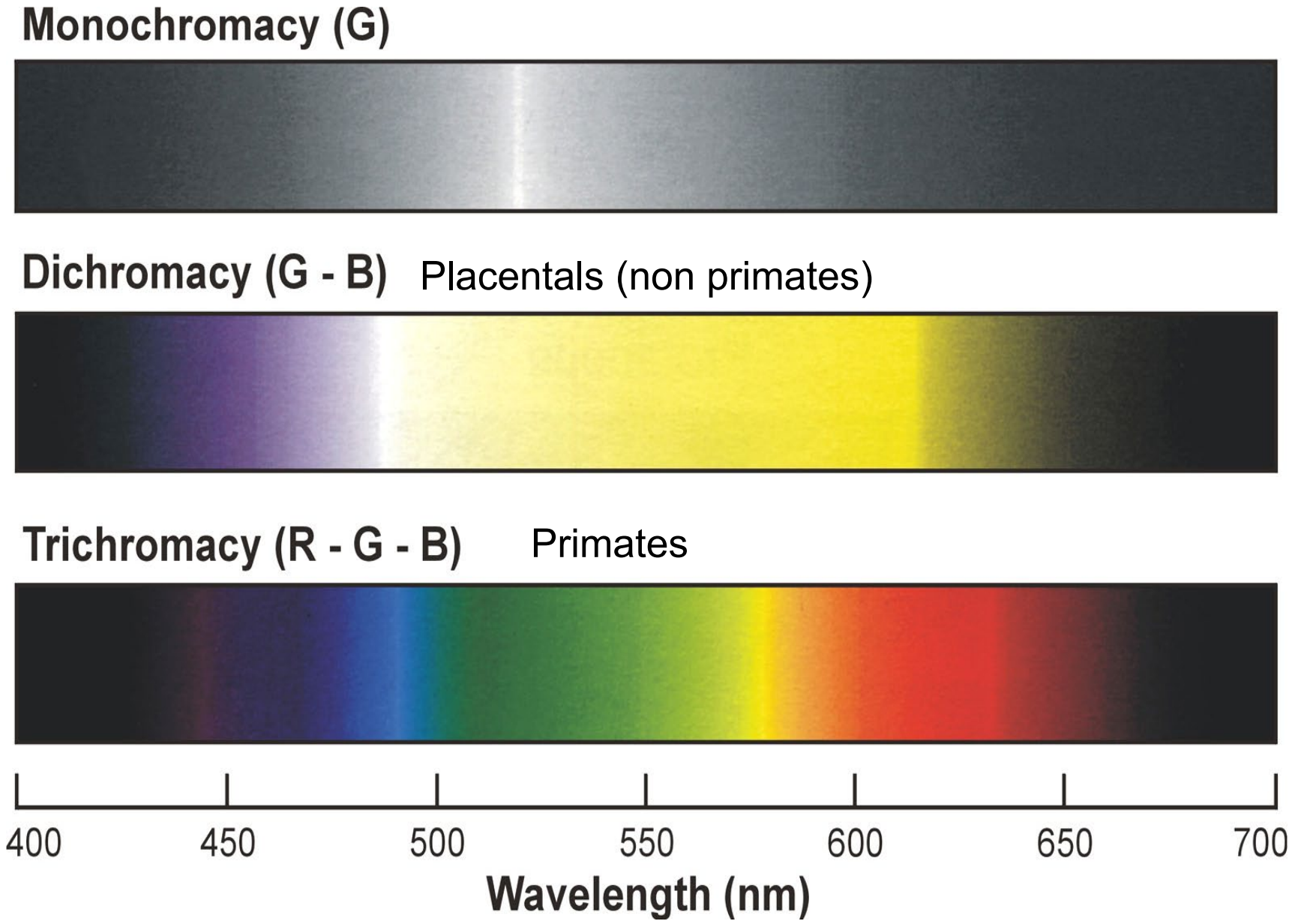
- three cone visual pigments = trichromacy
- third pigment re-evolved from duplication of M/LWS opsin gene - 45 mya
- no oil droplets or double cones



trichromacy

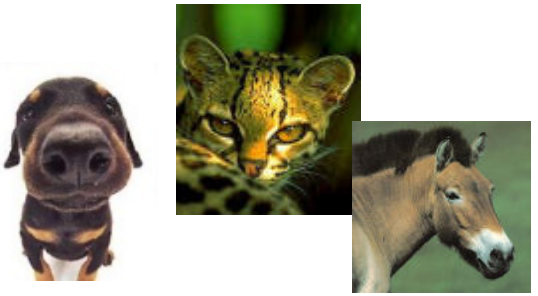
dichromacy

http://www.telegraph.co.uk/technology/news/11882403/New-app-lets-colour-blind-people-see-for-the-first-time-their-reactions-are-amazing.html


Monochromacy (G)
Dichromacy (G - B)
Placentals (non primates)
Trichromacy (R - G - B)
Primates
400
450
500
550
600
650
700
Wavelength (nm)

The story so far…

SWS1 SWS2 MWS LWS

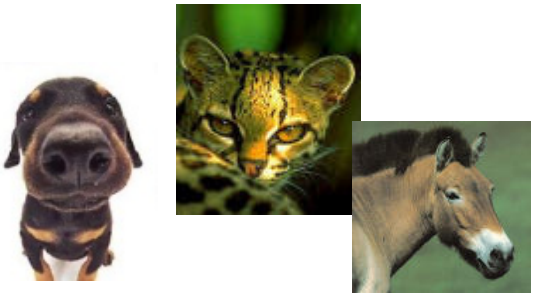


SWS1 ~~SWS2~~ ~~MWS~~ M/LWS

SWS1 ~~SWS2~~ ~~MWS~~ M/LWS ↔ M/LWS

Marsupials – a controversy

SWS1 SWS2 MWS LWS



SWS1 ~~SWS2~~ ~~MWS~~ M/LWS

SWS1 ~~SWS2~~ ~~MWS~~ M/LWS ↔ M/LWS

Marsupials???

SWS1? SWS2? MWS? LWS?

What should you know from this lecture?

Evolutionary history of opsins: from reptiles/fish/birds to mammals to primates

How oil droplets modify colour sensitivity